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Motorcycle Child Seat for Child with Special needs: Its Design Process and Problem-based Learning

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ABSTRACT

Most of child safety seats for motorcycle available in Indonesian market do not provide enough safety for the children passenger, especially for special needs child. This makes a special needs child cannot ride a motorcycle and prefer to use an automobile for their transportation means. However, it becomes a problem for a low-income family that can only afford a motorcycle. To address this problem, the present work aims to i) design a portable child safety seat for those with special needs that can be placed at the back side of the motorcycle, ii) provide safety feeling to the child by making a capsule-like shape for overall protection, iii) demonstrate an education case-study for mechanical design course. Discussion on how to determine the specification based on problem definition as well as the explanation on the design process of seat's frame and body are provided. This work can be also used a reference for problem-based learning in mechanical engineering design course.

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1. INTRODUCTION

Based on the data reported by the Statistics Agency of Indonesia, motorcycle is the most widely used vehicle in Indonesia by over 120 million units in 2018. People tends to use motorcycles because of its simplicity, affordable price, and flexibility. However, according to a report of motorcycle accidents, there are around 35,000 cases (the highest among other vehicles) in 2018 (Weber, *et al*., 2020). It makes motorcyclists becoming the most accident-prone person in the transportation area. Despite the risk, motorcycles still become the most favorite vehicle for most people in Indonesia.

According to the Ministry of Transportation of Indonesia, the standard of maximum passenger for a motorcycle is only 1 person with 1 other person as the driver. This regulation is made due to the safety of the driver as well as the passenger. Moreover, the regulation of children passenger also mentioned to be included in the previous regulation, where an additional children passenger cannot be put in front of the seat for safety reasons. Yet, many motorcyclists still bring their children and put them in front of the seat. Even, people outsmart the regulation using an additional seat for children made from rattan wicker material. Even though it seems safer, the additional seat in front space of the motorcycle is still not safe enough for both the driver and the children passenger due to its unfixed position to the motorcycle, uncomfortable position of the driver, and minimum safety equipment for the children if a crash or accident happens.

Children with disabilities (special needs child) face a significant challenge of being unable to live normally in Indonesia, as they could not be mobile easily from one place to another place. According to recent epidemiologic studies, 1.8 percent of the Indonesian population 'has serious problems' and 19.5 percent 'has problems' in different aspects of everyday activities (Kusumastuti *et al*., 2014). This can range from minor and infrequent impairments that limit the child's ability to engage in a wide range of activities to numerous and complex impairments that are constant and affect many aspects of the child's daily life (Dixon *et al*., 2021). One common issue faced by a family, especially those of lower income family, in relation to their child with disability is how hard they bring their child to visit a hospital as that is one of the frequent activities. In Indonesia, many people can only afford to use motorcycle instead of car. Therefore, a child safety seat for motorcycle that can give good protection and comfortable feeling to the child rider, i.e., a kid with special needs, as well as the driver is needed.

The present work proposed a design of child safety seat in motorcycles for children with special needs which focus on the safety and comfort of the children passenger. The seat's body and frame design, functionality, and aesthetic aspect are discussed. This work also can be referred a case-study of problem-based learning for mechanical engineering design course.

2. METHODS

2.1. Concept design

Based on *Undang-Undang Nomor 22 Tahun 2009* article 106, it says, "Every person who is riding a motorcycle without a side train which brings more than one passenger will be punished in a prison for one month or a fine of IDR 250,000 at most." A motorcycle should not have more than one passenger on it. There are three types of motorcycle child seats which are front-space seat, back-space seat, and side-space seat. Those are positioned with respect to the rider of the motorcycle. In this paper, the back-space seat is used due to the law made by the government and the safety aspect for both the driver and the passenger. The safety aspects have to fulfill several needs of the child: healthiness, comfort, and secureness. Children with the age ranging from three to six years old are very risky to be brought using

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motorcycles (Carvalho *et al*., 2010). Thus, as a middle way, a five-year-old motorcycle child seat is decided to be set as the priority of the main design in this paper.

Motorcycle child seats need to have some specifications to fulfill the safety and other aspects as it is one of the 'non-mandatory' safety tools of the motorcycles. The specifications are created to meet the proper and functional design of the child seat. Those specifications are: 1) The frame should be able to hold the given load from the seat; 2) The seat should fulfill the safety aspects including comfort and healthy aspect of the child; 3) Shape of the seat should protect the whole body of the child in the case of crashing and rolling; 4) The dimension of the seat should at least fit with five-years-old child body. Therefore, in order to achieve these specifications, the child seat should be designed properly and carefully.

The child seat itself consists of the seat frame (hard and strong material), seat outer shell (light and protective), inner shell (soft and comfortable), and air filter if possible. These components need to be designed carefully and analyzed its structural strength by finite element methods.

2.2. Synthesis and analysis procedure

As the first step of making a product, generating ideas for the model and the mechanism of the motorcycle child seat has been done through focus group discussion. Sketching and projecting how the design could be placed on the motorcycle is done as well in this process. The considerations of the design are about its reliability and simplicity when it is placed on the motorcycle. Moreover, another consideration includes analyzing the strength of the frame to hold a particular weight produced by the child's weight and the weight of the seat itself. In total, there are three sketches or mechanisms which are proposed to be the design of the motorcycle child seat. Among the three candidates, there will be only one chosen design as the final one at the end. It is either the combination of those three designs or one design.

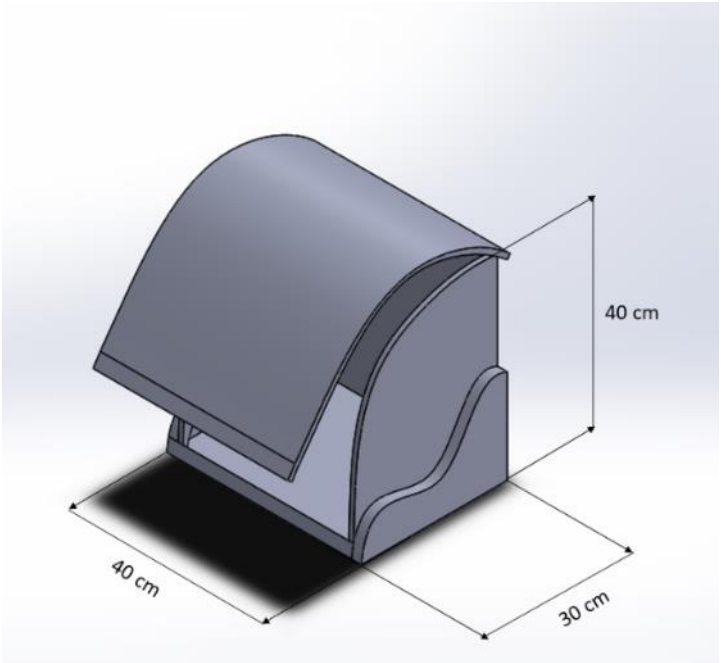

Figure 1. Design Candidate 1

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Figure 1 illustrates the sketch of how the first design candidate looks like. In this first design, it has a lot of parts such as the seat body, seat frame, pins, and roller at the back part of the frame. The frame will be installed permanently on the motorcycle, while the seat is portable. The roller at the back part is used to flip over the seat when the motorcycle needs to be fueled. Hence, there is no need to uninstall the seat from the frame. However, after going through some rough analyses and discussion, the design is unreliable. The four clicks on the frame needs to be very strong to hold that much weight coming from the seat. In other words, it will need a very strong material which will even add some more weight to the motorcycle. There are some advantages and disadvantages of the first design. The advantage is it has a capsule-like shape making the child inside it safe from any nuisance outside. Furthermore, the roller also eases the rider in case the motorcycle needs to be fueled. Even so, the disadvantages come from the support that hold the seat as it has explained before. Moreover, there is one marketed product which looks like this design.

The design candidate 2 is illustrated by **Figure 2**, the shape is more into a baby stroller. Compared to the first design candidate, this design only closes or protects the upper body of the child instead of the whole body. The roof can be flipped when it is not used so that it will not take a lot of space on the storage. The frame shape is different from the first one. Instead of using clicks, it uses a cylinder to attach the seat to the frame. There are some advantages and disadvantages coming from the second design. Unlike the first design, this one requires the rider to make sure that the fuel is already full before putting the seat on the frame. It is because the seat is not portable. The roof is not fully closed which is not safe to bring a child with special needs. This also means that it does not meet the specifications mentioned before. Since it is foldable, it does not need too much space on the storage.

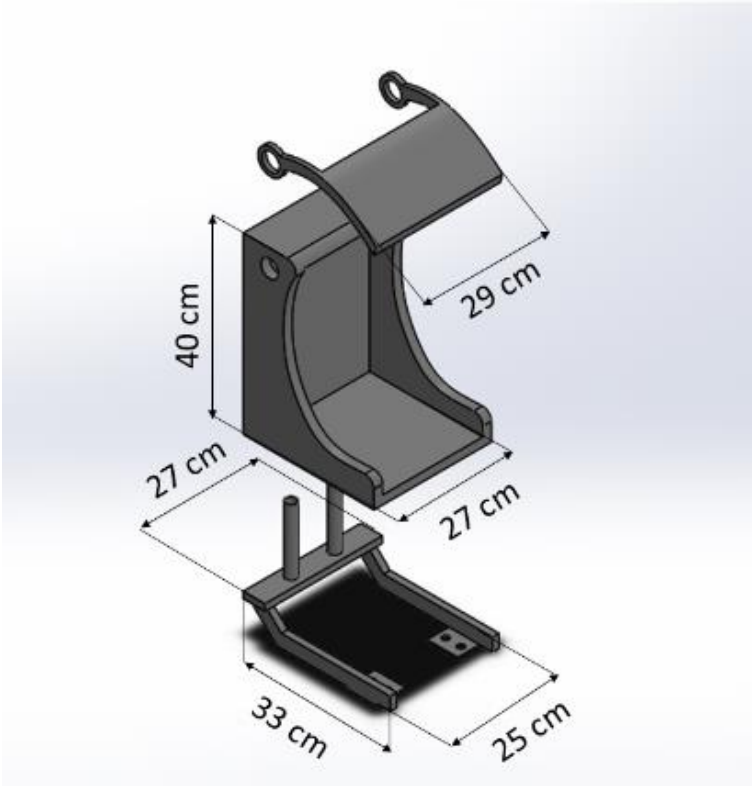

Figure 2. Design Candidate 2

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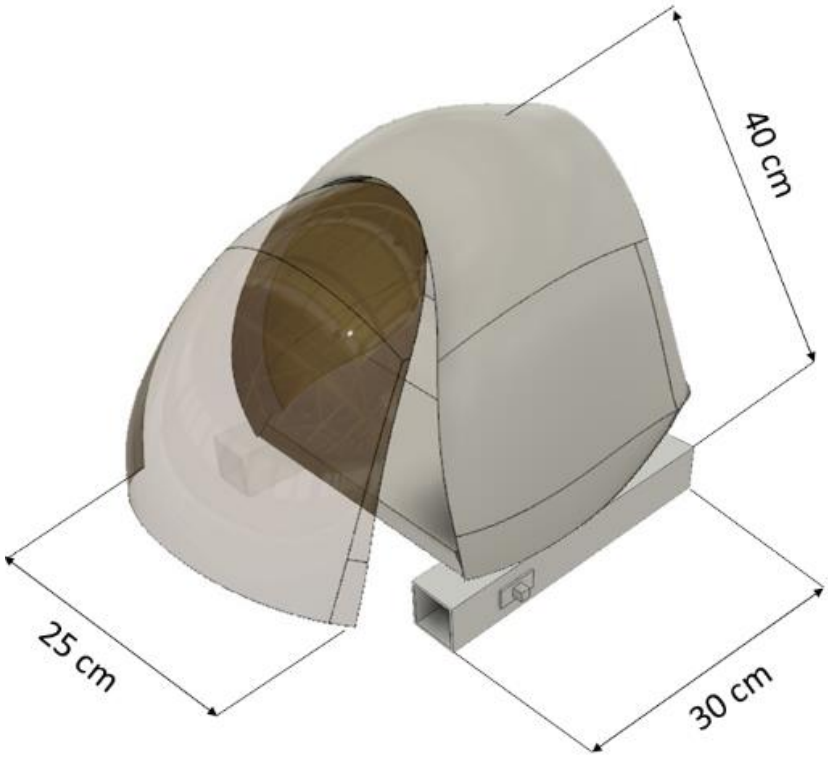

Figure 3. Design Candidate 3

In the third design candidate showed by **Figure 3**, it proposes the same shape of seat frame as the second design candidate. Instead of using some clicks, it is using a cylinder to put in the child seat into the frame. The frame is also similar to the previous two designs which will be installed permanently on the motorcycle. In this case, the cylinder will hold the weight of the seat and child when the motorcycle is moving. For the seat itself, it has a capsule-like shape, but it is not fully closed. It has a hole at the bottom part as a place for the child's feet. Hence, it only fits the feet rather than the whole body. The advantage of this design is that it is more reliable and simpler compared to the other two candidates in terms of the seat frame and body.

Each design has its own advantages, disadvantages, and uniqueness. There are some considerations to decide the most proper and suitable design for the motorcycle child seat. The considerations are based on the child's safety, comfort, and secureness by considering the condition of child with special needs who sometimes cannot protect themselves when collision or accident happen. The safest design of the seat body for the child is the first one. It provides a close environment which prevents any bad external factors from going into the seat, while the second and the third design have a portal for it to enter. On the other side, in terms of the support seat strength, the third design is the most reliable design to have. Design 1 has a greater potential of failure on the support part if it is used to hold a very great weight including the seat and child's weight. Even, there are some additional loads acted on it when the motorcycle is moving. It is almost unreliable to use only clicks to support the seat body. Considering the collection of the data and the project's objectives, the parts that need to be established are: 1) The frame which holds the entire body's weight, 2) 'Friendly' design of the seat body that can give the child a comfortable and safe environment.

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3. RESULTS AND DISCUSSION

In this paper, the focused area is on the parts of the child seat itself. The parts are divided into two big parts which are the frame and the seat body. The seat frame is made of AISI 1050 Cold-drawn Steel because it has some properties that are suitable to fulfil the functions. That kind of steel is very strong and long-lasting since it has a high yield strength and ultimate strength compared to the other steel (Baday *et al*., 2016). However, it is not as light as stainless steel. The material is homogenic, meaning that there is no other compound added to it. Since the frame is the one which holds the weight from the seat body, there are two main locking systems in which bolts will be attached to it. The originality of this design is on the cylinder part where the seat body will be placed. Many previous designs install the seat body permanently using a bolt or just using a rope. Besides the support, the seat body comes with a new shape compared to the existing product. Hence, there are two originalities of this product which is the shape of the seat frame and the seat body.

Other than the frame, there is another part that is also important for the motorcycle child seat. The seat body will include the padding, padding cover, glass, safety belt, cover, and the seat itself. The seat will be made of stainless steel. It is because of the anti-corrosion property of the stainless steel itself. It also has high strength and low in weight. For the padding, it will use foam, specifically metallic aluminum foam (Triawan *et al*., 2012). Moreover, Metal foams offers an excellent bending strength (Triawan *et al*., 2010) combined with its light weight since the thickness is in the range of 4-50 mm (Ravichandran *et al*., 2021; Triawan *et al*., 2020). The padding will be covered using a material called fabrics and vinyl. Those materials can withstand flammable experience, yet also washable. Since it will be used for children, color, durability, and fashion are the other considerations of choosing fabrics and vinyl as the material for the padding cover. Seat body cover will be made from acrylic because of the low in weight which is about 5 kg. Carbonate fibre is used as the glass since it provides anti-corrosion and waterproof properties (Sathiyamurthy *et al*., 2011).

A combination of design candidates 2 and 3 are chosen to be the final design of the child seat. The dimension of the seat frame is created so that it fits with the dimension of the back part of the motorcycle. As illustrated **in Figure 4**, the frame has a U-shape form which follows the shape of the rear part itself. For the seat body, the dimension is adjusted so that it will fit with the frame. **Figure 5**, **Figure 6**, and **Figure 7** describe how the product looks like from different angle. Those figures give an illustration on how it is attached with the frame as well. **Figures 8** and **9** show the dimension of the frame in more details. For the dimension of the seat body, it is the same as that in **Figure 3**.

As the future work, the proposed design will be evaluated for its mechanical strength by finite element method and the fabrication process for real application in a motorcycle (Zulaikah *et al*., 2020). Moreover, real test of motorcycle crash would be also needed to understand how the child seat can protect the passenger (Rahardian *et al*., 2021). In addition, this work can be also used a reference for education purpose in teaching a Machine Element course in Mechanical Engineering Study Program.

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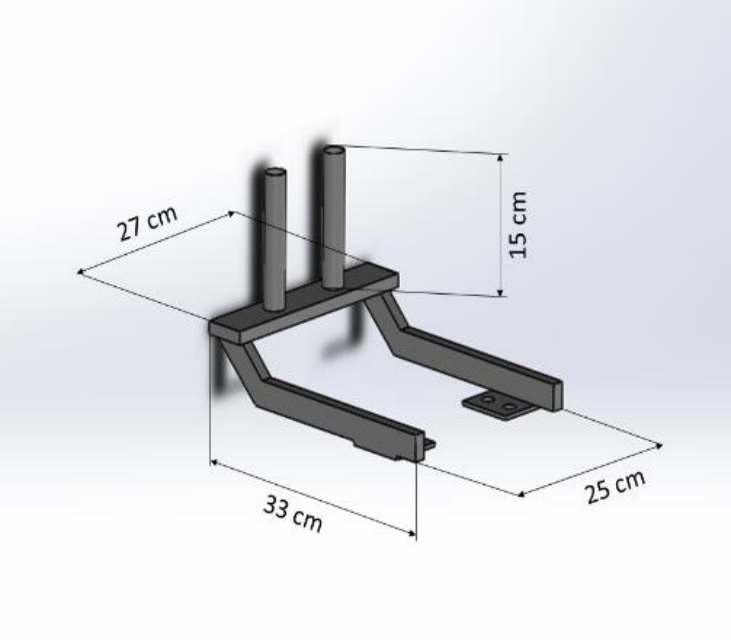

Figure 4. Seat Frame

Figure 5. Final design in isometric view

Figure 6. Final design from the side view

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Figure 7. Final design from front view

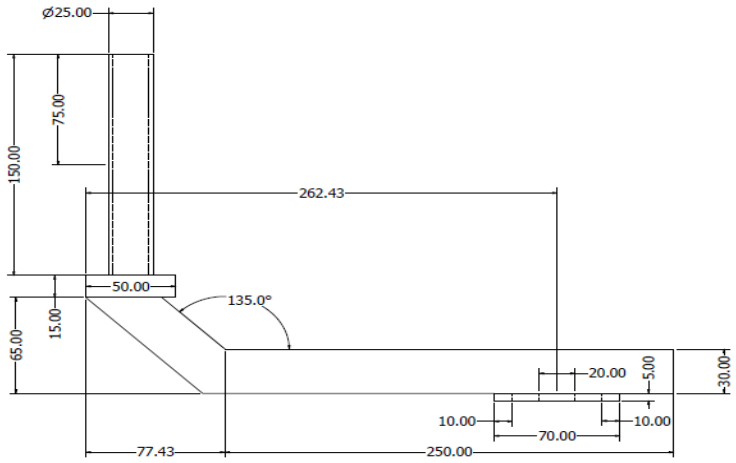

Figure 8. Seat frame dimension

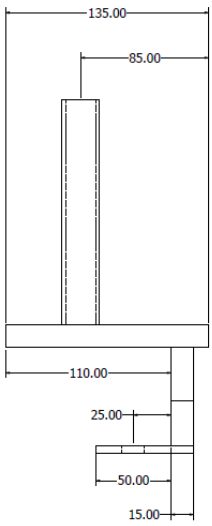

Figure 9. Seat frame dimension

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4. CONCLUSION

This paper presents the design process of child safety seat for motorcycle that can be used by children with special needs. The seat is designed to fulfill four main specifications: 1) The frame should be able to hold the given load from the seat; 2) The seat should fulfill the safety aspects including comfort and healthy aspect of the child; 3) Shape of the seat should be able to protect the whole body of the child in the case of crashing and rolling; 4) The dimension of the seat should at least fit with five-years-old child body. As a result, a capsule-like child safety seat that can give overall protection to the child passenger is introduced. The design is also portable as it can be attached strongly to the motorcycle frame as well as can be stored in the motorcycle's back compartment. To finalize the design, structural strength analysis by finite element method as well as its fabrication process will be done. This work can be used as a case study in machine element course in mechanical engineering major.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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